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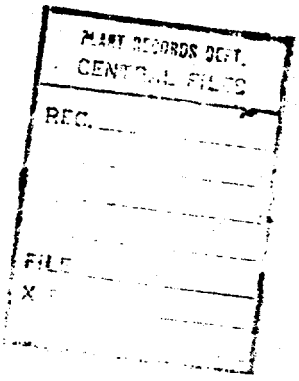
C. E. Rucker

Material Balance on
T and X at K-25

In a meeting in your office on October 25th, a letter from Col. Nichols to Mr. Center was discussed, wherein Col. Nichols requested information on the present state of material balances in the future. Col. Nichols was especially interested in accurate material balances as a guard against accumulation of a "critical mass" in the plant.

The attached memorandum by Mr. C. Daniel of the Statistics Section of the Process Analysis Department gives a review of the history of Material Balances at K-25 together with a summary of the present status of Material Balances and expected improvements.

G. A. Garrett



Carbide and Carbon Chemicals Corporation, Operating Contractor for the U.S. Atomic Energy Commission.

K-1586

October 28, 1946

Status of Overall Material Balance on T and X at K-25 - - C. Daniel

The importance of accurate material balances in the diffusion plant was clearly recognized by M. Benedict as early as January, 1945. Detailed statistical studies of the obtained and required precisions of the necessary measurements were started in April of that year. As soon as these studies produced definite recommendations, the Carbide management set up a special Material Accounting Section. At least three factors combine to give this problem its importance:

a. The rate at which the plant's metallic surfaces consume process gas is only roughly known from laboratory data. Productivity calculations for different operating conditions are limited in their usefulness if consumption is not accurately known. Accurate material balances on T and X will give valuable information on this point.

b. Control against possible diversion has many aspects but one important guarantee against theft is provided by material balances. Not only the value of the product but its effect on national safety make this aspect of material balance one of considerable urgency.

c. Under certain plant operating conditions the possibility of a spontaneous chain reaction occurring in corrosion products within the plant must be guarded against. Material balance may assist in setting an upper limit on such accumulations.

The report "Accounting for T and X in the Diffusion Plant", No. 2.16.13, by M. Benedict, C. Daniel and A. M. Squires, (April 3, 1946) gave a preliminary discussion of the factors affecting the precision and accuracy of overall material balances on T and X. The methods there proposed have been extended to current plant conditions, and many refinements, improvements, and short-cuts have been introduced. The Analytical and Research Laboratories, the Material Accounting Section, and the Statistics Section of the Process Analysis Department cooperate closely in these matters with the Operating Departments.

Table I summarizes the results of all the inventories and material balances run to date. Because of the nine factors listed below, however, the average values for Unaccounted-for T and X cannot be relied upon, nor can their stated precisions. The latter quantities represent the uncertainty in the quantities indicated due almost entirely to uncertainty in process variables; even these are in an unsatisfactory state. The stream-uncertainties and systematic errors in standards indicated below may well multiply these uncertainties by a factor as large as 5. These values cannot, therefore, be used to estimate consumption or accumulation of solid X or T inventory in the cascade. As soon as the nine factors listed below are studied, however, it is expected that overall material balances will suffice to determine the unaccounted for X within about 30 kg. per year (or within about 3 kg. per month, as explained in the report 2.16.13, see above).

Material balance at the present time can be used to detect accumulations of X in the plant of the order of 6-10 kg. between two inventories.

Further improvement may be looked for along at least three different lines. In the first place, a considerable number of measurement problems remain unsolved; secondly, some organizational or accounting obscurities remain to be cleared up; and finally, a material balance on U-234 can be used as a check.

Unsolved measurement problems include the determination of certain systematic errors as well as the estimation of the operating precisions of plant instruments and operation. There are nine of these that are known to be of considerable importance:

1. The chemical purities of the four main plant streams are not known with sufficient precision or accuracy. The purity of the normal feed is taken as 100.0% but may well average 99.95%. This is not a negligible difference.

2. The chemical purity of the partially depleted feed may be as low as 99.5%. This will make a large difference in the overall material balance on T.

3. The chemical purity of the waste stream is called 100% for material accounting purposes but may be off by some small amount, like 0.02%. The laboratory analyses given at present are unusable. Since they vary in both sides of 100% by as much as 1%.

4. The chemical purity of the product may well be as low as 99.0%.

5. Systematic errors in the standards used for isotopic analysis may be large enough to make large differences in the material balance on X. The absolute concentration of normal material will, we hope, soon be known with sufficient accuracy.

6. The accuracy of the waste-standards must also be known with a stated precision.

7. The accuracy of the measurements of product isotopic concentration must be determined within stated limits.

8. The precision with which fluorocarbon contaminant (C-816) is measured in the cascade is at present unknown and hence is not properly allowed for in the material balances.

9. The precision of measurement of light contaminant (C-74) in the cascade is likewise not known and hence not correctly allowed for.

Unsolved accounting problems probably also exist over and above these errors of measurement. The disappearance of 8 kg of X in August and its sudden re-appearance in the first week of September can hardly be an objective occurrence but must be an error of recording. The occurrence of apparent loss in unaccounted-for T, with a gain of unaccounted-for X also seem to indicate that some errors of recording are occurring.

The current situation may be summarized by stating that K-25 now has some large fraction of its inventory problems under control but it must be admitted that the condition originally required (as to maximum tolerable unaccounted-for U-235 per year) is not yet being met.

The values reported in Table I, then, cannot be used to judge upper limits on the possible accumulation of U-235 in the diffusion cascade, since too many of the nine factors mentioned above are assumed negligible in the absence of evidence. If we are to believe the figures in Table I, there has been no accumulation of T (or X) in the three months July 1 to October 1. There is, on the contrary, rather good reason to suppose however that about 270 kg of T ($\pm$70 kg) has been deposited during each month. Since the unaccounted-for T and X reported in Table I includes consumption (all corrosive products formed, all non-gaseous T-containing inventory) either the amounts reported, or their precisions, or both, are in error.

TABLE I

SUMMARY OF MATERIAL BALANCES AND INVENTORIES AT K-25 - UP TO 10/1/46

Dates	Change in Cascade Inventory		Cascade Material Balance Unaccounted Material	
	ΔKg T_c	ΔKg X_c	Kg T	Kg X
July 1 to August 1	$\pm$ 190	$\pm$ 112	- 20 $\pm$ 44	- 2.6 $\pm$ 1.6
August 1 to September 1	$\pm$ 116	$\pm$ 3	- 64 $\pm$ 44	$\pm$ 8.2 $\pm$ 1.9
September 1 to October 1	$\pm$ 200	$\pm$ 2.4	-320 $\pm$ 48	- 0.1 $\pm$ 2.0
September 1 to September 9	$\pm$ 68	- 2.1 ($\Delta X_{e,c}$)*		
September 1 to September 16	- 32	- 3.6 ($\Delta X_{e,c}$)		
September 1 to September 23	- 46	- 3.2 ($\Delta X_{e,c}$)		
September 1 to October 1	$\pm$ 16	$\pm$ 2.4 ($\Delta X_{e,c}$)		

The first three lines in this table include X and T in surge drums, cold traps and carbon traps. The last four lines include only X and T in active stages.

A plus quantity means a gain, a minus a loss.

* $X_{e,c}$ represents enriched X above feed concentration.